1^{st} Order Metal-Insulator Transitions: Are They Universal in Manganites?

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The classic approach to the metal-insulator transition (MIT) is based on the overlap of wave functions as in the tight-binding model. Double exchange (DE) in manganites provides added tuning of the overlap by spin.

Continuous MITs: vanishing-number (e.g., a gap); or diverging-mass (e.g., Mott-Hubbard system V_2O_3)

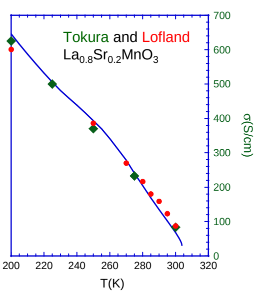
However Millis et al point out that DE is not enough--need localization mechanism above T_C, e.g., polarons.

1^{st}-order MITs: with Coulomb interaction (Mott); strong coupling to lattice, spin or orbital degrees of freedom

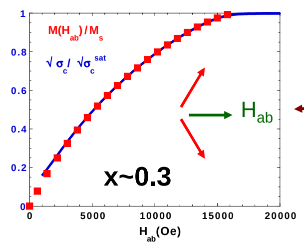
A continuous MIT is conventional wisdom in manganites: minimal hysteresis and scaling of magnetization in perovskite, $La_{0.8}Sr_{0.2}MnO_3$.

What have we learned?

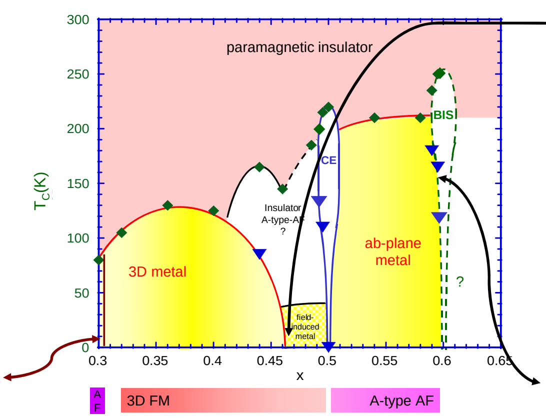
Transport in $La_{0.8}Sr_{0.2}MnO_3$ fits to thermally-activated hopping, $\sigma \sim \exp(T_{hop}M(T)/M_sT)$, without a concomitant MIT.



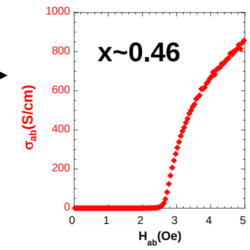
The AF stacking of FM metallic bilayers leads to a continuous MIT in $\sigma_c(H_{ab})$. (mass-diverging OR vanishing-number ??)



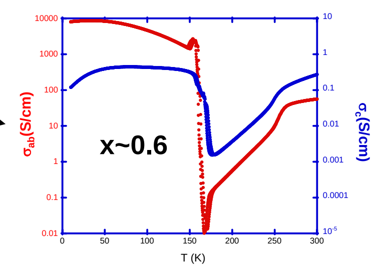
Bilayer manganites, $La_{2-2x}Sr_{1+2x}Mn_2O_7$



1^{st}-order MIT vs. H

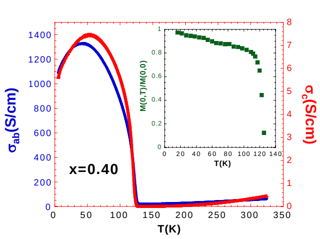


1^{st}-order MIT vs. T



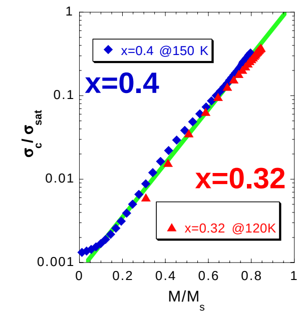
Questions

Is the 1^{st}-order MIT versus T for x=0.6 universal for DE manganites (e.g., x-0.4) ?



Can Anderson localization (due to random spin orientation and Hund's rule energy) explain the conductivity in PM insulator above T_C?

No sign of MIT above T_C in σ_{ab} or in $\sigma_c(H) \sim \exp(T_{hop}M(H)/M_sT)$, even if polarons melted by a magnetic field: implies polarons *alone* are not the localization mechanism above T_C



What is localization mechanism for x~0.46 in zero field? Is it gapped or Anderson localized?

Plans

Data, in addition to conductivity/magnetization, ideally *all* on the *same* crystal

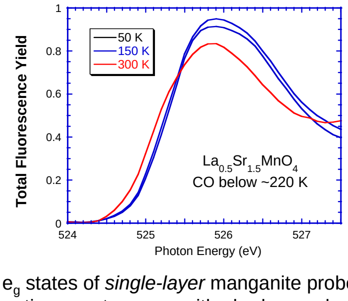
- tunneling (insulator gaps, metallic d.o.s.)
- polarization-dependent oxygen k-edge absorption (hybridized e_g states)

Theory: cluster calculations M. Van Veenendaal (NIU)

To do:

- Establish tunneling and oxygen k-edge absorption for metallicity, gaps
- Identify MITs or insulator-insulator transitions: address if 1^{st} or 2^{nd} order
- Except for c-axis of x=0.3, are MITs always 1^{st}-order in manganites?

Address whether a MIT occurs above T_C in a sufficiently high magnetic field



In-plane e_g states of *single-layer* manganite probed by x-ray absorption spectroscopy with ab-plane polarization.

Qing'An Li, K.E. Gray and J.F. Mitchell, Phys. Rev. B 67, 184426 (2003)

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